

## LA-UR-14-22440

Approved for public release; distribution is unlimited.

Title: Nuclear Physics: The Ultracold Neutron Source

Author(s): Kippen, Karen E.  
Clayton, Steven

Intended for: Brochure  
Web

Issued: 2014-04-10



### Disclaimer:

Los Alamos National Laboratory, an affirmative action/equal opportunity employer, is operated by the Los Alamos National Security, LLC for the National Nuclear Security Administration of the U.S. Department of Energy under contract DE-AC52-06NA25396. By approving this article, the publisher recognizes that the U.S. Government retains nonexclusive, royalty-free license to publish or reproduce the published form of this contribution, or to allow others to do so, for U.S. Government purposes. Los Alamos National Laboratory requests that the publisher identify this article as work performed under the auspices of the U.S. Department of Energy. Los Alamos National Laboratory strongly supports academic freedom and a researcher's right to publish; as an institution, however, the Laboratory does not endorse the viewpoint of a publication or guarantee its technical correctness.

## THE ULTRACOLD NEUTRON SOURCE

Ultracold neutrons (UCNs) provide a unique tool for researchers seeking a better understanding of the fundamental particles and interactions that govern the universe. Los Alamos National Laboratory's Ultracold Neutron Source provides those researchers with the world's highest density source of ultracold neutrons.

Ultracold neutrons are produced at Los Alamos National Laboratory by allowing higher-energy neutrons to interact with solid deuterium at low temperatures. The neutrons interact with the deuterium crystal in such a way that they lose almost all of their energy. Los Alamos scientists pioneered this method of producing ultracold neutrons, which is more efficient than previous techniques.

Ultracold neutrons move so slowly that they can be contained by magnet fields, special materials, or even gravity. This trapping allows more

time for precise measurement of their properties as well as their transportation. The Los Alamos Ultracold Neutron Source uniquely combines a high density of ultracold neutrons with the world's highest degree of polarization and low background from the spallation source.

The Ultracold Neutron Source is essential to advances in neutron experiments such as precisely measuring the neutron lifetime and other parameters of neutron decay. The unique features of the Los Alamos Ultracold

Neutron Source include a high density of ultracold neutrons with the world's highest degree of polarization and low background from the spallation source. The low background allows the use of specialized equipment such as large area silicon detectors that are vital for the next generation of neutron decay experiments.

The Department of Energy's Office of Science and the Laboratory's LDRD program fund experiments at the LANL Ultracold Neutron Source.



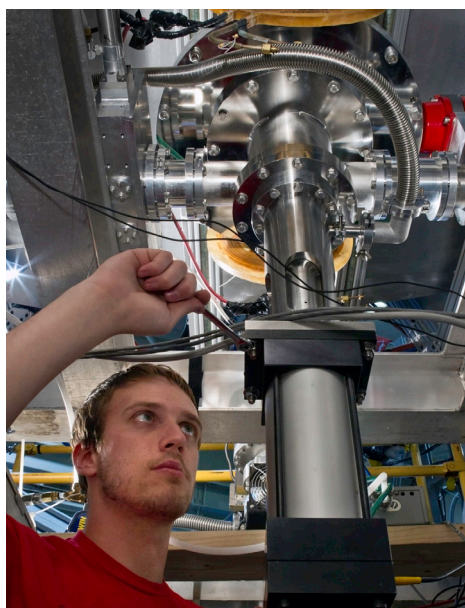
The special properties of UCNs are also being used to study the ablation of particles from actinide materials due to near-surface fissions. This is a topic of great interest to nuclear weapons performance. The large and tunable cross section for UCN (using gravity as an accelerator) allows surface fissions to be studied in a completely unique fashion.

**2004**

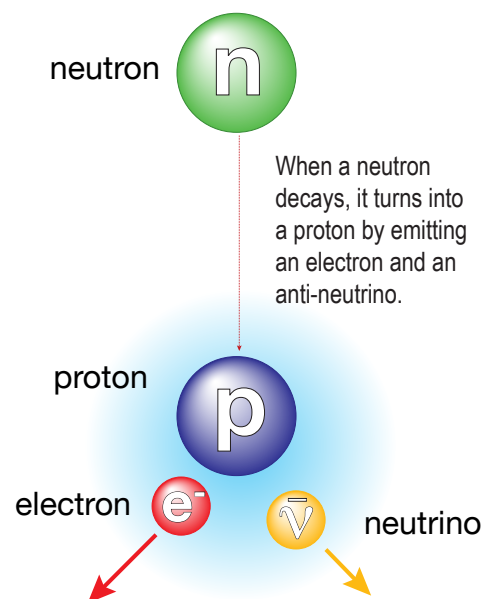
The year the Los Alamos facility was commissioned as the world's highest density source of ultracold neutrons

**less than  
6 meters  
per sec**

The speed at which ultracold neutrons move



Ultracold neutrons can be piped to different experiments, including a test port for user tests.



## ULTRACOLD NEUTRONS, CORRELATION, AND NEUTRON LIFETIME EXPERIMENTS

Los Alamos researchers, using the power and flexibility of the Laboratory's Ultra-cold Neutron Source, are conducting experiments providing new and undiscovered details of the weak nuclear force, one of the four fundamental forces of nature.

UCNA, the flagship experiment for the LANSCE ultracold neutron (UCN) source, examines the decay of polarized UCNs by measuring the correlation between the momentum of the decay electron and the parent neutrons polarization. Designed to test theories of what may lie beyond the current understanding of the particles and forces of the universe, this and future measurements are too large to be directly detected by any existing particle accelerator.

The UCNA experiment improves on limitations of previous experiments by using ultracold neutrons as its supply. Operating at LANSCE for five years, the experiment has recently published a measurement of the  $A$  coefficient competitive with the world's most precise—a measurement that has had a significant impact on the world average value. The Department of Energy's Office of Science and the National Science Foundation funded this work.

Los Alamos researchers are developing other correlation experiments that could utilize the UCN source. UCNB measures the correlation between the momentum of the decay anti-neutrino and the parent neutron spin. "Little  $b$ " is measured with unpolarized neutrons and probes the Fierz interference term.

The flagship of the Laboratory's future program is  $UCN\tau$ , an experiment to very accurately measure the lifetime of the free neutron. The experiment's novel UCN trap addresses systematic uncertainties in previous measurements made of the lifetime with bottled UCN, allowing it to push the precision of this important quantity to the sub-1 second level. The research on  $UCN\tau$  is funded by Los Alamos's Laboratory Directed Research and Development program.

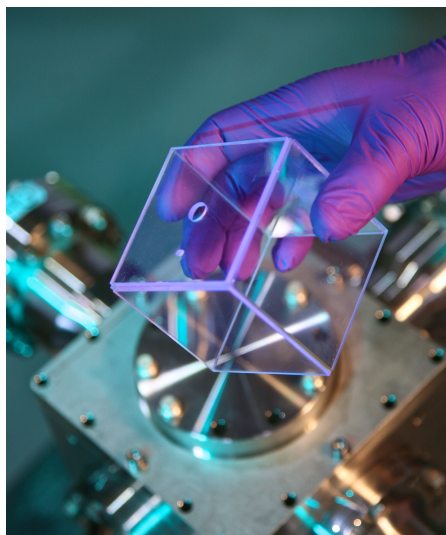


Looking into the UCNA spectrometer with beta detectors removed. Tubes overhead are cosmic ray veto detectors.

**< 1 sec**

The precision  $UCN\tau$  plans to ultimately reach

The "little  $b$ " apparatus, designed to measure the total energy associated with the decay of the neutron at the UCN facility.



*Our scientists and engineers investigate the field of nuclear physics through experiments that strengthen our fundamental understanding of matter, energy, space, and time.*

For more information, contact:

Mark Makela  
Subatomic Physics, P-25  
makela@lanl.gov  
505-667-5084